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DIABETES IN PREGNANCY IN NORTH CAROLINA

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ABSTRACT

This study examines the prevalence of diabetes mellitus among North Carolina residents giving birth in 1989-1990, as reported in vital and hospital discharge records. Estimates of the prevalence of diabetes were similar in both data sources. Approximately three percent of all deliveries were reported to have been diagnosed with either preconceptional or gestational diabetes. Of those deliveries diagnosed with diabetes, 78.7 percent involved gestational diabetes only, while 21.3 percent occurred among mothers with preconceptional diabetes.

Also examined were maternal risk factors associated with diabetes among live born infants, as reported on the birth certificate. Advanced maternal age was strongly associated with an increased risk for diabetes. After controlling for age, married mothers were slightly more likely to have been diagnosed with diabetes, compared to single mothers, while a marginally increased risk was observed for rural versus urban residents. Women with parity of three or more were less likely to have diabetes, after adjusting for maternal age. Mother's educational status was not a major risk factor for diabetes, after controlling for age.

Odds ratios for diabetes among whites versus other races varied by maternal age, with whites having a higher risk at younger ages (≤ 25 years) and mothers of black and other races having a greater risk at older ages (≥ 30 years). These findings are generally consistent with those reported in previous studies.

INTRODUCTION

Mothers with diabetes mellitus are at increased risk for a variety of adverse maternal and perinatal outcomes including preeclampsia, infection, fetal malformations, and perinatal mortality.¹⁻⁵ Although the availability of insulin and greater efforts to enhance preconceptional care have improved pregnancy outcomes for diabetic women, the risk for mortality and other complications among infants of diabetic mothers remains high compared to that in the general population.

The normal maternal metabolic adaptations of pregnancy place considerable demands on the mother's ability to regulate blood glucose. These changes may predispose a nondiabetic woman to develop symptoms of diabetes (glycosuria, abnormal glucose tolerance), and will often exacerbate the condition in mothers with pre-existing diabetes mellitus. Placental hormones, such as placental lactogen, placental insulinase, and estrogen, can cause an increase in maternal insulin resistance. This process is necessary to ensure an adequate supply of glucose to the rapidly developing fetus. If the maternal pancreas is unable to meet the need for increased endogenous insulin production, gestational diabetes may result. This generally occurs during the second and third trimesters, when the demands for insulin are highest.⁶

Estimates of the percentage of pregnancies complicated by diabetes vary widely, depending on the population at risk, method of case ascertainment, and case definition. Approximately 0.5 percent of pregnancies are affected by insulin-dependent diabetes.⁷ Estimates of the frequency of gestational diabetes (i.e., diabetes with onset during pregnancy) generally range between about one and five percent of all pregnancies, again varying by the method of ascertainment, demographic characteristics of the population, and case definition.⁸

About 80 percent of diabetes cases in pregnant mothers are of the gestational type. The risk for adverse pregnancy outcomes among women with

gestational diabetes is generally much lower than for mothers with preconceptional diabetes mellitus. This is particularly true for early spontaneous abortion and fetal malformations, which are usually manifested before the increased demands for maternal insulin lead to clinically evident gestational diabetes.

The purpose of this study is to determine the prevalence of maternal diabetes in North Carolina, as estimated from vital records and hospital discharge reports, and to describe some of the major demographic risk factors for diabetes in the pregnant population. This analysis was part of a larger project to develop and implement an ongoing surveillance system for diabetes in the state. This three-year project was supported by a cooperative agreement with the Centers for Disease Control.

METHODS

Estimates of the prevalence of diabetes among pregnant mothers were determined from vital records files (live birth and fetal death registrations) and from hospital discharge summaries. The purpose of this analysis was to compare the two data sources with respect to the reporting completeness and level of ascertainment of maternal diabetes, and to derive "best estimates" of the frequency of pregnancies with diabetes in the population.

Prevalence estimates from the two data sources were obtained for North Carolina residents who delivered (or who were discharged) between October 1, 1989, and September 30, 1990. We selected this period for analysis because the hospital discharge reports are compiled by the federal fiscal year. Because the hospital discharge data system captures discharges from North Carolina hospitals only, mothers identified as having delivered out of state were excluded from the vital records study sample.

For the hospital discharge data, records with DRG codes 370-375 were selected to identify patients who had been billed for labor and delivery services during the current hospital stay. Although

it is possible that this selection process may not capture 100 percent of the reported in-hospital deliveries occurring during a given period (for example, mothers whose primary reason for admission was other than delivery), the number of such births that are missed is likely to be very small. Because it is not possible to link maternal and infant discharge reports from the available data, the outcome of pregnancy (live birth or fetal death) could not be determined for deliveries identified from hospital discharge records.

Deliveries associated with maternal diabetes were those for which a diagnosis of preconceptional diabetes (ICD-9-CM code 648.0) or gestational diabetes/impaired glucose tolerance (ICD-9-CM code 648.8) was indicated on the discharge record. Prevalence estimates and 95 percent confidence intervals (CIs) were determined for overall maternal diabetes as well as for preconceptional diabetes (with or without mention of abnormal glucose tolerance test) and for gestational diabetes. In this analysis, we defined preconceptional diabetes as those cases with an ICD-9-CM assignment of 648.0; gestational diabetes was defined as those cases with an ICD-9-CM code of 648.8. Maternity patients with diabetes who did not deliver during the current episode of care (DRGs other than 370-375) were also identified and characterized according to type of diabetes.

For the vital records sample, all eligible live births and fetal deaths occurring during the study period were included. Presence of maternal diabetes was ascertained from a checkbox item for diabetes on the registration form. Records for which the presence of diabetes was unknown were excluded from all analyses. Prevalence estimates and 95 percent confidence intervals were determined for all deliveries and by pregnancy outcome (live birth or fetal death).

Demographic risk factors for maternal diabetes among live-born infants delivered during the twelve-month study period were determined from the infant's birth certificate. Odds ratios and 95 percent confidence intervals were calculated for diabetes associated with

selected maternal factors. Because age is one of the strongest risk factors for diabetes, adjusted odds ratios for each of the maternal characteristics controlling for age were also calculated using the Mantel-Haenszel procedure.⁹ Multivariable adjustment for confounding among the other risk factors examined was carried out with logistic regression.¹⁰

RESULTS

Prevalence of Diabetes

A search of vital records for the twelve-month study period identified 102,529 live births and 875 fetal deaths, for a total of 103,404 deliveries to North Carolina residents occurring in the state (Table 1). Overall, 154 (0.1%) of the records were excluded because of missing data, including 16 fetal deaths and 138 live births. The percentage of records with missing information on medical risk factors (including diabetes) was higher for fetal deaths than for live births (1.8% and 0.1%, respectively).

Table 1. Live Births and Fetal Deaths Among North Carolina Residents Delivering In-State, Oct. 1989 - Sept. 1990

	<u>Number</u>	<u>Percent</u>
Live Births	102,529	99.2
Fetal Deaths	875	0.8
Total Deliveries	103,404	100.0

From the hospital discharge records, 94,937 eligible deliveries were identified, covering approximately 92 percent of the live births and fetal deaths reported from vital records during the corresponding period of time. Sixty-three percent of these were uncomplicated vaginal deliveries; 18.4 percent were reported as Caesarean births with no additional complications (Table 2).

Table 2. Discharges From North Carolina Hospitals for Patients Receiving Labor and Delivery Services by DRG Assignment, North Carolina Residents Delivering In-State, Oct. 1989 - Sept. 1990

<u>DRG</u>	<u>Number</u>	<u>Percent</u>
C-section w/ complications (370)	4,913	5.2
C-section w/o complications (371)	17,491	18.4
Vaginal delivery w/ complications (372)	6,037	6.4
Vaginal delivery w/o complications (373)	59,805	63.0
Vaginal delivery w/ sterilization/D&C (374)	6,617	7.0
Vaginal delivery w/ other OR procedure (375)	74	0.1
Total	94,937	100.0

From the hospital discharge records, 622 mothers were diagnosed with preconceptional diabetes, representing 0.7 percent of all deliveries statewide (Table 4). A total of 2,303 women were diagnosed with gestational diabetes, or 2.4 percent of all deliveries in the state.

Table 4. Prevalence of Preconceptional and Gestational Diabetes Among North Carolina Residents Delivering In-State as Reported by Hospital Discharge Summaries, Oct. 1989 - Sept. 1990

<u>Diagnosis (ICD-9 code)</u>	<u>Number</u>	<u>Percent</u>
Diabetic		
Diabetes Mellitus (648.0)	622	0.7
Gestational Diabetes (648.8)	2,303	2.4
Total Diabetic	2,925	3.1
Nondiabetic	<u>92,012</u>	<u>96.9</u>
Total Deliveries	94,937	100.0

A total of 3,101 deliveries (3,074 live births and 27 fetal deaths) identified from vital records were reported as having had maternal diabetes, compared with 2,925 such deliveries reported in the hospital discharge records for the same period. The percentage of deliveries with diabetes was quite consistent between vital records and hospital discharge reports (3.0 and 3.1, respectively) (Table 3). Although a slightly higher percentage was reported in the hospital discharge data, this difference was not statistically significant ($z = 1.06$, $p = 0.289$ two-tailed). The prevalence of maternal diabetes also did not vary by pregnancy outcome--3.0 percent of live births and 3.1 percent of fetal deaths were reported to have involved maternal diabetes.

Table 3. Prevalence of Maternal Diabetes by Data Source, North Carolina Residents Delivering In-State, Oct. 1989 - Sept. 1990

	<u>Vital Records</u>			<u>Hospital Discharge</u>
	<u>Live Births</u>	<u>Fetal Deaths</u>	<u>All Deliveries</u>	
Percent Diabetic	3.0	3.1	3.0	3.1
95% CI	2.9-3.1	1.9-4.2	2.9-3.1	3.0-3.2

Of the 2,925 delivering mothers diagnosed with either type of diabetes, 21.3 percent had preconceptional diabetes, while 78.7 percent had gestational diabetes (Table 5). In contrast, among gravidas with a discharge diagnosis of diabetes but who did not deliver during the current hospital stay (patients with DRG assignments other than 370-375), 45.9 percent had been diagnosed with preconceptional diabetes--more than twice that of mothers who delivered.

Table 5. Frequency and Percentage of Pre-Existing and Gestational Diabetes Among Delivering and Non-Delivering Maternity Patients, North Carolina Residents Hospitalized In-State, Oct. 1989 - Sept. 1990

<u>Diabetes Type (ICD-9 code)</u>	<u>Deliveries (DRGs 370-375)</u>	<u>Non-Deliveries (Other DRGs)</u>
Diabetes Mellitus (648.0)	622 (21.3)	532 (45.9)
Gestational Diabetes (648.8)	2,303 (78.7)	628 (54.1)
Total Diabetic	2,925 (100.0)	1,160 (100.0)

Risk Factors for Maternal Diabetes

The frequency of diabetes increased markedly with advancing maternal age (Table 6). Teenaged mothers were the least likely group to have reported diabetes (0.7%), while mothers aged 35 years or older had the highest frequency (6.6%).

Table 6. Percentage of Mothers Having Diabetes by Age Group, With Associated Odds Ratios and 95% CIs, North Carolina Residents Delivering In-State, Oct. 1989 - Sept. 1990

Age Group	Percent Diabetic	Odds Ratio ¹ (95% CI)
≤ 17	0.7	0.4 (0.3-0.5)
18-24	1.8	1.0
25-29	3.2	1.8 (1.6-2.0)
30-34	4.7	2.6 (2.4-2.9)
≥ 35	6.6	3.8 (3.4-4.3)

¹Odds ratios for each age group calculated relative to the odds for diabetes among mothers 18-24 years of age.

The risk for diabetes was much lower for teen mothers, compared to women 18-24 years of age (OR = 0.4). For women aged 25-29 years, the odds of being diagnosed with diabetes was 1.8 times that of mothers aged 18-24, while for 30-34 year-olds the odds ratio increased to 2.6. Mothers aged 35 years or older were 3.8 times as likely to have been diagnosed with diabetes, compared to women 18-24 years old.

In addition to maternal age, five demographic risk factors were examined for their association with diabetes: race; marital status; education; rural/urban residence; and parity. Rural areas were defined as unincorporated locations or areas with population less than 2,500. Most of the associations were confounded, to some degree, by maternal age (Table 7). Unadjusted odds ratios were highest for married mothers (OR = 1.9) and mothers with at least a high school education (OR = 1.6). However, when controlled for age, these risks were changed substantially. For married mothers, the adjusted odds ratio was 1.3.

Controlling for age, high school education was no longer associated with an increased likelihood of being diagnosed with diabetes. In fact, among the older mothers, having at least a high school education was somewhat protective overall.

Table 7. Odds Ratios and 95% CIs for Diabetes According to Selected Maternal Risk Factors, North Carolina Residents Delivering In-State, Oct. 1989 - Sept. 1990

Risk Factor	Unadjusted OR (95% CI)	Adjusted OR ¹ (95% CI)
Mother's Race		
Black & Other ²	1.0	
White	1.2 (1.1-1.3)	(Not Computed)
Marital Status		
Single ²	1.0	1.0
Married	1.9 (1.7-2.1)	1.3 (1.2-1.4)
Education		
< High School ²	1.0	1.0
≥ High School	1.6 (1.4-1.7)	0.9 (0.9-1.0)
Residence		
Urban ²	1.0	1.0
Rural	1.1 (1.1-1.2)	1.1 (1.1-1.2)
Parity		
None ²	1.0	1.0
1-2	1.2 (1.1-1.3)	0.9 (0.9-1.0)
≥ 3	1.3 (1.1-1.5)	0.8 (0.7-0.9)

¹Adjusted for maternal age

²Referent level

Controlling for age, mothers with parity of 1 or 2, or parity ≥ 3 were slightly less likely to have reported diabetes, compared to nulliparous women (adjusted OR = 0.9 and 0.8, respectively). When age was not adjusted, higher parity appeared to be positively associated with diabetes. Rural residence was associated with a slightly increased risk for diabetes and was not changed when controlled for age (crude and adjusted OR = 1.1).

To further examine the associations presented in Table 7, we also carried out a logistic regression analysis, simultaneously controlling for maternal age, race, marital status, education, rural/urban residence, and parity (results not shown). The results of this analysis were consistent with those based on the adjustment for age alone, and suggest that there was little or no additional confounding present among the variables after controlling for maternal age.

Based on the unadjusted odds ratio shown in Table 7, the risk for diabetes appeared to be slightly higher among white mothers compared to mothers of black and other races. Because this risk was found to vary substantially by maternal age, odds ratios for race were computed after stratifying by maternal age (Table 8). Whites aged ≤ 17 or 18-24 were more likely to have had diabetes reported on the birth certificate than were black and other mothers of similar age. The odds ratios for white mothers aged ≤ 17 was 1.9; for whites 18-24 years of age the odds ratio was 1.6. For women 25-29 years of age, there was no difference in the risk for diabetes between the two race groups (OR = 0.9; 95% CI 0.8-1.1). Among women aged 30-34 or ≥ 35 , whites were less likely to have been reported as having diabetes compared to mothers of black and other races. Odds ratios for these age groups were 0.8 and 0.7, respectively.

Table 8. Odds Ratios¹ and 95% Confidence Intervals for Diabetes According to Race, Stratified by Maternal Age, North Carolina Residents Delivering In-State, Oct. 1989 - Sept. 1990.

Age	Black and Other	White
≤ 17	1.0	1.9 (1.1-3.6)
18-24	1.0	1.6 (1.4-1.9)
25-29	1.0	0.9 (0.8-1.1)
30-34	1.0	0.8 (0.7-0.9)
≥ 35	1.0	0.7 (0.6-0.8)

¹Odds ratio for whites in each age group calculated relative to mothers of black and other races.

The likelihood of a woman being diagnosed with diabetes is probably influenced by her level of prenatal care participation; diabetic women with more complete participation would have a greater chance of being diagnosed than would diabetic mothers who received less prenatal care. Because prenatal care utilization is strongly associated with certain maternal characteristics, we also computed the odds ratios presented in Tables 6-8 controlling for Kessner index (results not shown). This adjustment resulted in little or no change in the risk ratios described above.

DISCUSSION

This study found that approximately three percent of all deliveries in North Carolina are diagnosed with maternal diabetes. However, the vast majority of these cases involve gestational diabetes only. The prevalence of preconceptual diabetes mellitus among pregnant women is estimated to be about seven per 1,000 deliveries. These findings are generally consistent with those of similar studies reported in the literature. The prevalence of diabetes among fetal deaths, which was similar to that observed for live-born infants, was somewhat lower than would be expected based on other reports. While these findings may be an indication of improved obstetric care of pregnancies complicated by diabetes so that fewer fetal deaths result, they are more likely due to underreporting of maternal medical complications on the fetal death certificates.

The prevalence of diabetes in pregnancy was remarkably similar in both the hospital discharge and vital records study samples. These findings were somewhat unexpected in view of studies from other states which found substantial underreporting of medical risk factors on the birth certificate. Our results suggest that the level of ascertainment of maternal diabetes on the birth certificate is comparable to that of hospital discharge records.

The prevalence estimates derived from the hospital discharge and vital records data were also in reasonably close agreement with those obtained from

a registry of diabetes and pregnancy in Cleveland County, North Carolina. This registry, which employed active surveillance of medical records for case identification, reported 5.1 percent of deliveries as having been diagnosed with diabetes. This compares with a reported frequency of 4.4 percent for hospital discharge and vital records data for Cleveland County residents during the same period of time. These findings suggest that ascertainment of maternal diabetes from the hospital discharge summaries and vital records is approximately 86 percent complete. Because of differences in diagnostic criteria, case definition, and other factors, these prevalence estimates should be compared with caution.

Our study found a strong association between advanced maternal age and the risk for diabetes. Teenaged mothers, who are generally at increased risk for a variety of pregnancy complications, had the lowest proportion of diabetic pregnancies among all the age groups. Consistent with previous clinical and epidemiologic findings, it was the older mothers who were most likely to be diagnosed with diabetes.

Although mothers with at least a high school education initially appeared to be at increased risk for diabetes, this association was due to the fact that these mothers tended to be somewhat older than women with less than a high school education. When controlled for age, education was no longer a significant risk factor for diabetes. Slightly increased risks were found for married mothers, after adjusting for age. It is possible that part of the increased risk for married women may be due to more complete reporting and/or better diagnosis of diabetes among these women compared to unmarried mothers. However, this assertion was not supported when the data were further adjusted for adequacy of prenatal care utilization.

The initial finding of an increased risk for diabetes among high-parity women was also due to confounding with maternal age. After controlling for age, mothers with parity of 1-2 or ≥ 3 were slightly less likely to have been reported with diabetes compared to women with no previous births.

The age variation in the risk for diabetes observed among whites versus other races is difficult to explain. It is possible that genetic factors may play a role, with whites having a greater predisposition for developing gestational diabetes at younger ages, and blacks being more likely to develop the disease at older ages. Such differences could not be examined in the present study, since information regarding type of diabetes is not available on the birth certificate, while mother's race is not reported on the hospital discharge record.

Recent improvements in the management of diabetes during pregnancy have greatly reduced the risk for perinatal mortality and other adverse outcomes among diabetic mothers.¹¹ In order to enhance the effectiveness of such clinical interventions, more effort is needed to identify those mothers at greatest risk. For reproductive-aged women with pre-existing diabetes mellitus, this requires planned pregnancies to ensure adequate metabolic control pre-conceptionally. For all mothers, early entry and adequate participation in prenatal care is essential for reducing the risks for adverse outcomes associated with diabetes.

Additional studies of diabetes in pregnancy among North Carolina residents are currently underway. The aim of these studies is to examine the risks for adverse pregnancy outcomes among mothers with diabetes, including obstetrical and perinatal complications, congenital malformations, and infant mortality.

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